Instructional Systems Design and the Learning Sciences: A Citation Analysis

☐ Joshua A. Kirby
Christopher M. Hoadley
Alison A. Carr-Chellman

Learning sciences (LS) and instructional systems design (ISD) are two related fields that have shared interests in the application of technology for advancing human learning. While the two fields may have different values, boundaries, and in some cases methods, they also share significant overlap of content and purpose. We examine the relationship between the two fields through a citation analysis of three journals in each of the respective fields. The findings of the study indicate that the amount of cross-field publication is low, but there exists a trend for increased cross-field citation. As cross-field publication increases, we suggest that the existence of invisible colleges that link the fields will become more salient.

☐ In this article, we examine two fields, each having vested interest in studying technologies for learning: instructional systems design (ISD)[1] and the learning sciences (LS). As described in a recent special issue of the journal *Educational Technology* entitled "Learning Sciences and Instructional Systems: Beginning the Dialogue" (Carr-Chellman & Hoadley, 2004a), these are two fields of research that are both concerned with education, technology, and learning environments, and to some extent, design. In the present article we attempt to further discussion of these two fields by turning, for the first time, to an empirical citation analysis.

Defining fields of research is tricky: The unique characteristics can be difficult to identify clearly, and the boundaries can become fuzzy. The aforementioned special issue had lengthy discussion of the definitions of the fields of ISD and LS. Roughly, we see ISD as primarily concerned with the design of materials for learning and as Hoadley (2004) has stated, "with the best ways to create systems that yield learning" (p. 8). ISD has presented technologies for learning since the days of filmstrips, yet is still considered a relatively adolescent field of study that really

1 We recognize several terms as possible descriptors for ISD, including *educational technology, educational media, instructional design, instructional technology, instructional systems,* and *instructional systems technology*. In general these terms are not interchangeable. Indeed, educational technology and educational media are generally seen as narrower concepts than, say, instructional systems as a nomenclature, and the former tends to be more focused on hard technologies. However, despite these distinctions, we use the term *instructional systems design* to address the entire field that may be encompassed by all of these terms.

came into its own in the 1950s with the advent of military uses for instructional technology (Saettler, 1967). Whereas ISD has traditionally focused on the creation of human systems of instruction and, even more broadly, learning, in recent years the field has also come to encompass issues associated with systemic change and organizational innovation.

A similarly cursory definition of the LS field might emphasize tools and learning. LS is more closely related to cognitive sciences and promotes the scientific understandings of learning as seen through the lens of technology. Kolodner (2004) defined learning scientists as those who "harvest theories of active, constructivist, and participatory learning to design software and learning environments and ways of educating that promote deep and lasting learning" (p. 37). Although both fields use educational technology as part of their identity, it is our contention that these two fields do not overlap as much as one might expect. In this article, we describe some empirical data from a citation analysis to support our claim about these two research communities.

It is difficult to create a formal definition of what a community is about. Observers often turn to manifestations of a research community such as professional societies, academic departments, publication outlets, or conferences to help define a community. The research we report here is no different; we have defined the community, in this case, through the hallmark publication outlets for each of the fields or disciplines. We recognize that we could have approached this by looking at different academic preparations, by surveying graduates, professors, or current students to identify leaders, seminal publications, or cornerstone concepts. There are a large number of ways to define academic communities: by their leaders, their thinkers, their doers. In our work, we have taken a first step in helping to define these fields by examining their outward and obvious manifestations, that is, their published literatures.

Given their common interest in educational technologies, it would be reasonable to expect the communities to overlap. Why have these two fields been separate up until now? Apart from historical accident, there are many differences between the two communities, including goals, theories, methods, and epistemologies (Hoadley, 2004). ISD, as the name implies, has traditionally worked within instructionist models of learning (Reiser, 2001a, 2001b), whereas LS has been more oriented toward information-processing models of learning, or constructivist approaches (Kolodner, 1991). Also, LS began with questions related to models of learning (Kolodner, 1991), whereas instructional systems has been about questions of design (Reigeluth, 1999). These framings have important implications for the ways practitioners of the two fields do their work, but we suggest that the reason the two communities have grown interested in each other is the increasingly related nature of scientific understanding or modeling of learning and design-oriented work that aims to change learning in some way (Design-Based Research Collective, 2003; Hoadley, 2002). We see great promise in integrating research from both communities to better understand and create educational technologies.

The evidence linking the two fields goes beyond a shared interest in educational technology. For instance, there have been recent movements toward integration, including the hiring of several LS professors at major university ISD programs, such as Penn State and the University of Georgia. In addition, prominent ISD faculty at Indiana University and the University of Missouri are spearheading the addition of degree programs in LS. These sorts of curricular changes are compelling evidence that the two fields are not only related, but may be becoming more and more interconnected.

METHOD

In contrast with the aforementioned special issue of *Educational Technology* that deals with these relationships on a philosophical level (e.g. Carr-Chellman & Hoadley, 2004a), this article provides an empirical citation analysis to examine to what degree the two fields of ISD and LS are integrated. In particular, we wanted to see if the two communities have overlapping membership, and whether the two communities are aware of and make use of each other's research.

Our initial perception was that there were some important individuals who linked the two communities, but we hoped to quantify through our analyses exactly how linked the communities are. Below, we describe citation analysis generally, then describe how we operationalized the two communities we studied, and finally provide a description of the scope and types of data collected.

Citation Analysis

In this article, we examine the relationship between ISD and LS, as demonstrated by citation analysis (Crane, 1972; Garfield, 1972). Citation analysis is the formal quantitative analysis of the literature produced by a field and the relationships among people as evidenced by whom they cite in their published articles. Especially in academic disciplines where the importance of publication and citation are high, the bibliographic references used in research documents can be an important mirror of how people in a field construe it. Citation analysis can be used for many purposes. For instance, it is used as a tool for journal evaluation (Garfield), identification of subgroups or invisible colleges (Crane; Sachs, 1984), identifying the shared knowledge of a community (Small & Greenlee, 1980), or characterizing disciplines or communities (Chubin, Porter, & Rossini, 1984).

Citation analysis is one method in a larger category of literature-based studies known as bibliometrics (Paisley, 1989). Bibliometrics focuses on the patterns of scientific communication, with the premise that journal (and other publication) citations are an important indicator of these patterns (Rice, Borgman, & Reeves, 1988). Bibliometrics is a quantitative method of studying the scholarly communication within and between fields, and

> . . . does not impute motives or effects to the participants in a scientific communication network. It monitors the number and types of messages in various channels . . . [and] . . . is used to quantify levels of scientific activity and to identify linkages among individuals and groups in the network. (Paisley, 1989, p. 704)

In particular, citation analysis is a surface form of content analysis that analyzes only the citations referenced in a publication (such as the References, Works Cited, or Bibliography sections of an article), as opposed to analysis of the prose of each publication (Crane, 1972; Garfield, 1972). Here we contrast our study's method with two other methods. Our approach is to describe the relationship between the members of two fields of study as observed in representative published literature, where we attempt to answer general questions about how well the membership of each field knows the other. Another bibliometric method used elsewhere requires the researcher to tally the reciprocation of citation among groups of authors within a defined corpus of literature, and analyze the cohesiveness of the messages produced by the members of each group. A third method used in other studies involves an attempt to identify the interaction of an invisible college of experts about a particular subject (which will be discussed next). One strength of citation analysis is that the method produces "conceptually suggestive" clustering or mapping of research publications, which could "be interpreted as networks of interpersonal contacts" (Lievrouw, 1989, p. 617).

The term *invisible college,* when used among those who study scientific communication, generally refers to a virtual bond that exists among scholars of a particular topic who communicate regularly with each other even though those scholars are not colocated at the same academic university or institution (Crane, 1972). The gist of the invisible college concept is that scholars are connected through their acts of communication regardless of their geographic proximity, and that idea sharing causes scientific knowledge to grow—thus the source of the ideas influences the knowledge that emerges. Invisible colleges theoretically could be found in formal and informal communication networks (e.g., publications vs. coffee talk at conferences). But as Crane's seminal work discussed, bibliometric analysis of formal communication provides the ability only to infer about the informal networks, because the informal networks of communication would be impossible to observe, and self-report data of the participants would be of questionable accuracy (Lievrouw, 1989). The importance of invisible college membership is put into perspective when we consider the potential influence that a loosely unified collective has over members of related fields by determining the relative importance of research problems, and researchers' access to funds that contribute to solving those problems (Price, 1986).

Operationalizing the Two Communities

The ISD community (at least in North America) is probably best defined by a professional society: the Association for Educational Communications and Technology (AECT). This organization sponsors two of the publications we analyzed and has strong ties to instructional systems programs or departments in universities around the world. The two publications are *TechTrends*[2] and *Educational Technology Research and Development (ETR&D)*. We also chose to include the magazine *Educational Technology*, which has been connected with the ISD research community since its inception in the 1960s.

The LS community is somewhat harder to delimit because it is much newer than ISD. Some of the first uses of the term *learning sciences* were for the International Conference of the Learning Sciences held at Northwestern University's Institute of the Learning Sciences in 1991 (the conference was originally part of the Artificial Intelligence in Education, or AI-Ed, conference series) and the *Journal of the Learning Sciences (JLS)*, which was founded at the same time to bring together cognitive scientists and others studying education. Recently, a professional society, the International Society of the Learning Sciences, was founded to unite these two publication venues and a third, the Computer Supported Collaborative Learning (CSCL) series. We analyze all three publications in the citation analysis that follows.

Although any number of publication outlets might have been considered for this analysis, we selected these specific journals and conference proceedings out of an intuitive sense that these were the seminal or flagship scholarly outlets in our respective fields. Surely it would be possible to include any number of other journals, and others have pointed out the lack of international representation in our analysis. However, we felt that the journals we selected, although not necessarily comparable to one another, are reflective of the overall trends in each of the fields. Corroborating our selections is Holcomb, Bray, and Dorr's (2003) recent article in *Educational Technology*, which reports on a survey on perceptions of publication outlets in the ISD field. Although only an example, and representative of only the ISD field, the article clearly identifies *ETR&D* as the most highly considered journal by academic prestige, while *TechTrends* is the fourth most read, and the third most used journal in classrooms. *Educational Technology*, although a nonrefereed publication, was ranked second for general reading, and first for classroom use in this same survey. This research was not available at the time that we selected the journals that we analyzed, but provided further justification for the choices we made during the study.

Both of the target communities study educational technology. Obviously, ISD journals or magazines such as *Educational Technology* or *ETR&D* encompass research on educational technologies. Likewise, the stated scope of *TechTrends* is the "practical applications of technology in education and training."The CSCL conferences are explicitly about computer-supported learning, and although technology is not in the title of the JLS or the International Conference of the Learning Sciences (ICLS), these outlets encompass educational technology. The ICLS 2002 call for papers identifies "design and study of new learning technologies or the appropriation and use of technology by a learning community" as a theme covered by the conference. Of the 105 articles in JLS catalogued by PsychInfo from 1991–2001, 8 include *technology* (technol*) or a variant of the word *computer* (comput*) in the title, and 33 include these words in the abstract. Over half (59) of the articles have words beginning with *technol, comput, media*, or *multimedia* anywhere in the record.[3]

2 *Tech Trends* was a nonrefereed journal for many years, and in 1998 became a refereed journal with traditional peer review processes. However, the focus of the journal has continued to be targeted at practitioners rather than more traditional academic research and scholarship.

3 Searches were performed on the PsychINFO database via the ERLWebSPIRS5 system provided by Ovid on Jan. 12, 2004.

Scope and Sources of Data

Slightly more than a decade (1991–2001) of six publication outlets were analyzed for this study, with three outlets representing each field. The publications were chosen based on their representativeness of contemporary research and theory in the ISD or LS fields, their popularity among scholars and practitioners in those fields, and the suitability of the publication for citation analysis. For instance, although the AECT annual conference series was seen as an important venue for the ISD field, we were concerned about analyzing the proceedings given that not all conference papers were included and many proceedings papers might differ substantively from the corresponding presentations. Based on these criteria, we selected *ETR&D, Educational Technology,* and *TechTrends* as representatives of the ISD community. For the LS publications we analyzed *JLS,* the *Proceedings of the International Conference of the Learning Sciences,* and the *Proceedings of the Computer Supported Collaborative Learning Conference.* Although these six publications differ in significant ways (see Table 1), such as review mechanisms, typical manuscript length, author guidelines, and so forth, we thought that each was highly representative of its field. (A much wider bibliometric analysis or triangulation with other methods would be required to prove this.) We also chose to focus our efforts on predominantly North American publications, in part to keep the scope of the work manageable, and in part because we did not wish to add more complexity to the analysis due to geographic divisions within each field.

The citations at the conclusion of all articles in all six publications from 1991–2001 were reviewed. The target of our search was to find citations from each field's publications to works published in the other field. For example, when reviewing the works cited in *JLS* articles, we recorded the number of citations to articles published in *ETRD, Educational Technology,* and *TechTrends.*

Then our analysis turned to the authors of the citing and cited articles. Our analysis differentiated between an author's citation of his or her own work and the citation of another author's work. When author names varied (for instance, because of name changes or alternate abbreviations), they were manually standardized.

Although our primary focus was on cross-field citations, we also estimated the total number of citations (including those that did not cross fields). Within-field citations (e.g., when an

Table 1 ☐ Sources selected.

Publication	*Format*	*Review*	*Audience*	*Sponsor*	*Community*
Educational Technology Research & Development	Journal	Peer	Predominantly researchers	Association for Educational Communications and Technology	ISD
Educational Technology	Magazine	Editorial	Researchers and practitioners	Ed Tech Publications	ISD
TechTrends	Journal	Peer (was editorial)	Practitioners and researchers	Association for Educational Communications and Technology	ISD
Journal of the Learning Sciences	Journal	Peer	Researchers	International Society of the Learning Sciences	LS
Computer-Supported Collaborative Learning	Conference proceedings (Bi-annual)	Peer	Predominantly researchers	International Society of the Learning Sciences	LS
International Conference of the Learning Sciences	Conference Proceedings (Bi-annual)	Peer	Predominantly researchers	International Society of the Learning Sciences	LS

Note: ISD = Instructional Systems Design; LS = Learning Sciences article in *ETR&D* cited *TechTrends*) were not counted separately as part of this analysis.

RESULTS

The total number of articles, citations, and authors found is summarized in Table 2. Overall we tabulated results from 2,090 articles across the six publications. We also included the CSCL 2002 conference as if it had occurred in 2001, because the conference was originally scheduled for late 2001 but was delayed until January 2002 and would have left a gap in the series. A total of 1,265 articles came from ISD field sources, and 825 from LS sources.

In total, 2,608 unique authors wrote these articles. Organizations (such as the Cognition and Technology Group at Vanderbilt) were treated as a single author, whereas each personal author of a multiple-author paper counted as a separate author. The number of unique authors for each publication does not add up to the total number of unique authors because of overlap; some authors who published in multiple venues are counted only once in the total unique authors for each field, and only once in the overall total number of unique authors.

Every citation in all 2,090 articles was examined to find the cross-field references, which were then noted in a database. We calculated an average number of citations per article for each publication by randomly selecting 10% of the issues of the serial publications, or 10% of the articles in each of the proceedings, and calculating the arithmetic mean of total citation counts for those samples. We estimate that we examined nearly 44,000 citations from all six publications for the date range examined.

How many people belong to both communities, as represented by their published work? Of the 2,608 unique authors in our analysis, only 66 (2.5%) have published articles in both fields. Only 13 authors (0.498%) published in both

Table 2 ☐ Articles, citations, and authors examined.

Publication	*Format*	*Number of Unique Authors*	*Number of Articles*	*Estimated Citations per article*[a]	*Estimated Total Citations*[a]
ISD Publication Outlets					
ETR&D	Journal	405	325	39.9	12,966
Educational Technology	Magazine	781	698	19.2	13,402
TechTrends	Journal	293	242	10.0	2,420
ISD Total		1,479	1,265		28,788
LS Publication Outlets					
JLS	Journal	247	158	29.4	4,645
CSCL	Conference Proceedings	669	344	16.2	5,573
ICLS	Conference Proceedings	636	323	15.2	4,910
LS Total		1,552	825		15,128
Grand Total		3,031	2,090		43,916

Note: [a] Estimated citations per article was based on the average number of citations per article of a subsample of 10% of the data; the estimated total citations were calculated by multiplying estimated citations per article by the (exact) number of articles in the data.
ISD = Instructional Systems Design; LS = Learning Sciences
ETR&D = Educational Technology Research and Development; JLS = Journal of the Learning Sciences; CSCL = Computer-Supported Collaborative Learning; ICLS = International Conference of the Learning Sciences

Table 3 ☐ Cross-field citation counts.

ISD publication outlets	*Citing JLS*	*Citing ICLS*	*Citing CSCL*	*Total Citing LS*
ETR&D	60	0	11	71
Educational Technology	37	1	0	38
TechTrends	3	0	0	3
ISD Total	100	1	11	112
LS publication outlets	*Citing ETR&D*	*Citing ET*	*Citing TT*	*Total Citing ISD*
JLS	11	14	3	28
CSCL	12	18	2	32
ICLS	5	21	1	27
LS Total	28	53	6	87
Total				199

Note: ISD = Instructional Systems Design; LS = Learning Sciences
ETR&D = Educational Technology Research and Development; JLS = Journal of the Learning Sciences; CSCL = Computer-Supported Collaborative Learning; ICLS = International Conference of the Learning Sciences; ET = Educational Technology; TT = TechTrends

peer-reviewed journals analyzed (*ETR&D* and *JLS*). If we use publication as a means of determining membership in a research community, our analysis therefore shows that few people belong to both communities. Although this approach is not the only way to identify people who may belong to both communities, these results may contribute further evidence of the bifurcation of these two groups. Crossover authors are presented in two ways: Appendix A shows those authors who wrote articles for the two flagship journals for the respective fields, *ETR&D* and *JLS;* Appendix B identifies the larger group of scholars who have written in at least one outlet in each field (e.g., *TechTrends* and *JLS*, or *Educational Technology* and *CSCL*).

Are the two fields aware of each other's work? The number of cross-field citations for each publication is shown in Table 3. There were 112 citations of LS literature in the three ISD publications, out of an estimated 28,788 citations, yielding an average cross-field citation rate of 0.4%. There were 87 citations of ISD literature in the three LS publications, out of an estimated 15,128 citations, yielding an average cross-field citation rate of 0.5%. Thus, although the cross-field citation rates are quite low, they are similar, implying that each field is equally aware (or unaware) of the other field's literature.

How many of the cross-field citations are due to self-citation? We developed a formula for partitioning citations from self-citations. Thus, if Jane Smith published an article in *JLS* that cited one of her own articles in *ETR&D*, this would be a self-citation. We did not distinguish between self-citation of a single-author article versus a multiple-author article; if Smith's *JLS* article cites Smith and Wesson in *ETR&D*, this is still one self-citation. However, for the citing article, attribution was divided equally among the authors. For example, if Smith and Barney's article in *JLS* cited Smith and Wesson in *ETR&D*, this would be 0.5 self-citations for Smith and 0.5 nonself-citations for Barney. Table 4 shows cross-field citations with self- and nonself-citations broken out. We found that 14.17 citations, or 7.1% of the 199 total cross-field citations, were due to self-citation, revealing that cross-field citations were *not* solely due to crossover authors citing themselves.

Table 4 ☐ Nonself- (NS) and self- (S) citations across fields

	ISD publication outlets							
	Citing JLS		*Citing CSCL*		*Citing ICLS*		*Total Citing LS*	
Publication	*NS*	*S*	*NS*	*S*	*NS*	*S*	*NS*	*S*
ETR&D	56.5	3.5	9.88	1.12	0.0	0.0	66.38	4.62
Educational Technology	36.0	1.0	0.00	0.00	1.0	0.0	37.00	1.00
TechTrends	3.0	0.0	0.00	0.00	0.0	0.0	3.00	0.00
ISD Total	95.5	4.5	9.88	1.12	1.0	0.0	106.36	5.62
	LS publication outlets							
	Citing ETR&D		*Citing ET*		*Citing TT*		*Total citing ISD*	
Publication	*NS*	*S*	*NS*	*S*	*NS*	*S*	*NS*	*S*
JLS	7.6	3.4	13.5	0.5	2.25	0.75	23.35	4.65
CSCL	11.0	1.0	17.0	1.0	2.00	0.00	30.00	2.00
ICLS	4.0	1.0	20.1	0.9	1.00	0.00	25.10	1.90
LS Total	22.6	5.4	50.6	2.4	5.25	0.75	78.45	8.55
Grand Total							184.83	14.17

Note: ISD = Instructional Systems Design; LS = Learning Sciences
ETR&D = Educational Technology Research and Development; JLS = Journal of the Learning Sciences; CSCL = Computer-Supported Collaborative Learning; ICLS = International Conference of the Learning Sciences; ET = Educational Technology; TT = TechTrends

DISCUSSION

Limitations

Citation analysis is an expensive and imperfect process. Myers and DeLevie (1966) designated this type of study "the most laborious bit of instrumentation ever proposed" (p. 246), and Cotton and Anderson (1973) suggested "berserk work" (p. 273) as an appropriate name for the process. In conducting this citation analysis, we faced numerous difficulties that are indicative of the effort that must be expended to familiarize oneself with another community. Apart from the typical citation analysis woes of information gathering and hand counting, we were confronted with defining each community well enough to pick the most representative publications; because we had coauthors trained in each community an intuitive guess was easy, but lengthy discussions about how to prove typicality or centrality were fruitless or suggested work of an even more daunting scale. We were forced to rely on our (educated) intuition.

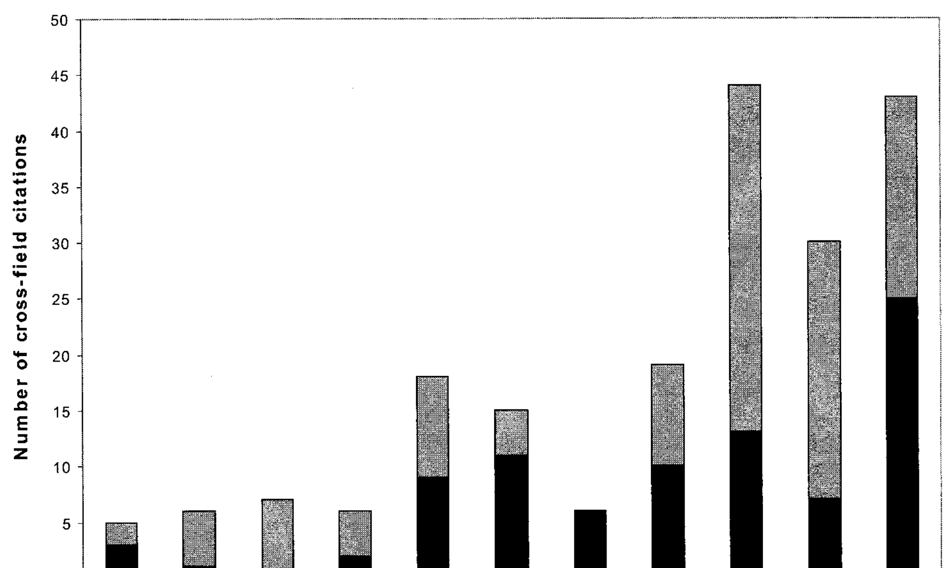
Likewise, assembling materials across the two communities was logistically difficult. Libraries tended to subscribe to one community's literature or the other but not both, and the recent formation of the International Society of the Learning Sciences meant that its publications did not even emanate from a single publisher over the run of the series (for instance, *CSCL* had a different publisher each time the conference occurred). Computerized literature indexing services such as OCLC, Current Contents, the Web of Science (Social Science Citation Index), and ERIC did not consistently index the six publications (surely due, in part, to several of the publications not being archival journals). Some volumes, commonplace on the bookshelves of researchers in one or the other community, were nearly impossible to locate through libraries. We had to order copies of one proceedings via interlibrary loan from the British Library—our major research university's library could not obtain a copy domestically; obtaining others required us to travel hundreds of miles to the library of another university. Clearly, the lack of ready access to these publications inhibits researchers from crossing fields. In our case, it took more than six months to acquire the set of literature analyzed for this article. Another limitation is that our analysis ended with works published in 2001, and cross-field activity of the past two years is not fully recognized.

Conclusions

This citation analysis clearly suggests that despite the shared interest in educational technology, the ISD and LS communities are largely distinct. With only 0.4% to 0.5% of citations referring to the literature of the other community, and only 2.3% of authors shared across the two fields, these two groups are generally isolated from each other. A small number of scholars do cross the boundaries between the two fields, and interestingly, these scholars seem to be prominent researchers in the two communities.

Is this situation changing? We did a cursory examination of cross-field citations by year (see Figure 1), but it was difficult to interpret because of the varying numbers of articles per year. However, it did appear that the trend was toward greater cross-field citation. The year 1999 had a large number of cross-field citations, due in part to a special issue of *ETR&D* (Ross, 1999) in which many LS researchers had been invited to present their work. Interest across the two fields may be increasing based on other observations we have of the field. For instance, Penn State University's Instructional Systems Program recently hired two new faculty members who are specialists in LS. The ISD faculty at Indiana University at Bloomington was recently helping to found an LS program (Duffy, personal communication, August 11, 2003). Additionally, Stanford University recently added an LS doctoral program, but chose to add the term *technology design* to the program title. A session at the American Educational Research Association's annual meeting (Kirby et al., 2003),

Figure 1 ☐ Instructional systems design (ISD) and learning sciences (LS) cross-field citation count, by year.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
ISD citing LS	2	5	7	4	9	4	0	9	31	23	18
LS citing ISD	3	1	0	2	9	11	6	10	13	7	25

Year

which discussed the intersection of the research interests of ISD and LS, was well attended and generated a great deal of interest among members of both communities. And while experts differ in their opinions of whether ISD and LS should converge, experts in both fields agree that they have something to say to each other (Carr-Chellman & Hoadley, 2004b). We take this as early evidence that there is growing interest in bridging the existing chasm that separates the two fields. We also suggest that there is great promise in coalescing research from these two communities in the service of better educational technologies for human learning. However, we understand that this coalescence is not a simple matter.

The first significant challenge for bridging the two fields is increased awareness, and we hope that this article will be an appropriate first step in that direction. Raising this awareness is not, however, an easy task. Any newcomer to a field faces numerous questions about who is who and what is what within that community, but mentors, advisors, colleagues, or formal schooling usually scaffold them through the process. Field bridgers rarely have such organized assistance.

The second challenge is that the values in these two fields are not necessarily shared. Specifically, to the extent that ISD is founded more on design methodologies and theories, but LS is founded more on cognitive science and educational psychology in particular, these two fields are not necessarily on equal footing within the academy. In general, design tends to command less status than science in our society, and these two fields are not immune to this differential. These status differences are seen within the context of university preparation by Carr-Chellman (2004):

> One theory regarding why the learning sciences enjoy high status within institutions . . . is that their preparation differs significantly from that of instructional designers. The learning scientist is often trained in research and development institutes or laboratories and is enculturated into the grant-writing and research community, in short, they are trained to aim their efforts at those endeavors which tend to be rewarded in the academy.
>
> Meanwhile, the instructional technologist continues to struggle with their colleagues requesting assistance with using Powerpoint[®] for their biology lectures. Instructional Systems programs prepare students for practice as well as traditional research posts . . .. Perhaps partially because of this intractable problem of the theory-to-practice dualism, the recognition of the instructional technologist as a scholar in their own right has been historically difficult for many in the academy to accept. (p. 42)

Thus, the values associated with the preparation, as well as the foundations, of the two fields may tend to separate rather than unite them, creating fewer crossovers between these scholars and practitioners, who all may be concerned with the use of technologies for advancing human learning.

The challenges to link any two fields are numerous. The reason for facing this challenge while the realized connection between ISD and LS is still in its infancy is so that the leadership of entities (scholarly publication outlets, professional associations, etc.) that represent these fields can set precedents early, which will lead in joint intellectual growth and mutual benefit. Based on his extensive sociological study of scientific communication, Herbert Menzel (1966) wrote that in the course of the development of the scientific professions:

> [They have] worked out a rich set of customs, habits, traditions, mechanisms, tricks, and devices as to how one goes about obtaining information, what one does by way of screening and listening for information, and what one need not listen or attend to. Planners of information policies must take into account this body of behavior patterns, of traditions, customs, and learned behavior. (p. 1002)

As our citation analysis has shown, the connection between ISD and LS is established and is beginning to grow. Conscious effort to implement principles of quality scientific communication learned from previous generations may mitigate the continuing growing pains as stronger bonds are formed between these two fields.

We believe that efforts to link the fields will be worthwhile, because the combination of the two communities—one that has thought carefully about design, and one that has thought carefully about cognition in context—has the best chance of effecting meaningful change in education through the creation and effective application of technology-enhanced learning environments. □

Joshua A. Kirby, Christopher M. Hoadley, and Alison A. Carr-Chellman are with the College of Education, Learning and Performance Systems Department, Instructional Systems Program, The Pennsylvania State University. Christopher M. Hoadley is also with the School of Information Sciences and Technology at Penn State.

Thanks to Carol A. Wright, of The Pennsylvania State University's Education Library, Amy Zediak, and the staff of the Hillman Library at the University of Pittsburgh, for invaluable assistance.

This research was funded in part by NSF grant number REC-0231981 and the Learning and Performance Systems Department of the College of Education at Penn State.

Thanks to Steven Ross and the anonymous reviewers for their helpful comments on earlier versions of this manuscript. The opinions expressed are those of the authors alone.

Correspondence concerning this article should be addressed to Christopher M. Hoadley, Instructional Systems Program, 314D Keller Building, University Park, PA 16802-1303 [ETRDarticle@tophe.net].

REFERENCES

Carr-Chellman, A. A. (2004). Instructional systems, learning sciences, design, technology: A more complete pathway. *Educational Technology, 44*(3), 40–44.

Carr-Chellman, A. A., & Hoadley, C. (2004a). Learning sciences and instructional systems: Beginning the dialogue [Special issue]. *Educational Technology, 44*(3).

Carr-Chellman, A. A., & Hoadley, C. (2004b). Conclusion: Looking back and looking forward. *Educational Technology, 44*(3), 57–59.

Chubin, D. E., Porter, A. L., & Rossini, F. A. (1984). "Citation classics" analysis: An approach to characterizing interdisciplinary research. *Journal of the American Society for Information Science, 35*(6), 360–368.

Cotton, M. C., & Anderson, W. P. (1973). Citation changes in the *Journal of Counseling Psychology. Journal of Counseling Psychology, 20*(3), 272–274.

Crane, D. (1972). *Invisible colleges: Diffusion of knowledge in scientific communities.* Chicago: University of Chicago Press.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

Garfield, E. (1972). Citation analysis as a tool in journal evaluation. *Science, 178,* 471–479.

Hoadley, C. (2002). Creating context: Design-based research in creating and understanding CSCL. In G. Stahl (Ed.), *Computer Support for Collaborative Learning 2002* (pp. 453–462). Mahwah, NJ: Lawrence Erlbaum Associates.

Hoadley, C. (2004). Learning and design: Why the learning sciences and instructional systems need each other. *Educational Technology, 44*(3), 6–12.

Holcomb, T. L., Bray, K. E., & Door, D. L. (2003). Publications in educational/instructional technology: Perceived values of ed tech professionals. *Educational Technology, 43*(3), 53–57.

Kirby, J., Barab, S. A., Duffy, T., Carr-Chellman, A., Hay, K. E., Hoadley, C., et al. (2003, April). *At the intersection of instructional systems and the learning sciences, does anyone have the right of way?* Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Kolodner, J. L. (1991). *The Journal of the Learning Sciences:* Effecting changes in education. *Journal of the Learning Sciences, 1*(1), 1–6.

Kolodner, J. L. (2004). The learning sciences: Past, present, future. *Educational Technology, 44*(3), 34–40.

Lievrouw, L. A. (1989). The invisible college reconsidered. *Communication Research, 16*(5), 615–628.

Menzel, H. (1966). Scientific communication: Five themes from social science research. *American Psychologist, 21*(11), 999–1004.

Myers, R. A., & DeLevie, A. S. (1966). Frequency of citation as a criterion of eminence. *Journal of Counseling Psychology, 13,* 245–246.

Paisley, W. (1989). Bibliometrics, scholarly communication, and communication research. *Communication Research, 16*(5), 701–717.

Price, D. J. d. S. (1986). *Little science, big science—and beyond.* New York: Columbia University Press.

Reigeluth, C. M. (1999). What is instructional-design theory and how is it changing? In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. II, pp. 5–29). Mahwah, NJ: Lawrence Erlbaum Associates.

Reiser, R. A. (2001a). A history of instructional design and technology: Part I: A history of instructional media. *Educational Technology Research and Development, 49*(1), 53–65.

Reiser, R. A. (2001b). A history of instructional design and technology: Part II: A history of instructional design. *Educational Technology Research and Development, 49*(2), 57–67.

Rice, R., Borgman, C. L., & Reeves, B. (1988). Citation networks of communication journals, 1977–1985: Cliques and positions, citations made and citations received. *Human Communication Research, 15*(2), 256–283.

Ross, S. M. (1999). Contemporary developments in educational technology design and evaluation: Special issue part II. *Educational Technology Research and Development, 47*(2), 5–6.

Sachs, S. G. (1984). Citation patterns in instructional development literature. *Journal of Instructional Development, 7*(2), 8–13.

Saettler, L. (1967). *A history of instructional technology.* New York: McGraw-Hill.

Small, H., & Greenlee, E. (1980). Citation context analysis of a co-citation cluster: Recombinant-DNA. *Scientometrics, 2*(4), 277–301.

See Appendixes, next page.

Appendix A ☐ Authors Publishing in both *Journal of the Learning Sciences* and *Educational Technology Research and Development*, in alphabetical order ($N = 13$).

Barab, Sasha A.	Hmelo, Cindy E.	Schwartz, Daniel L.
Bransford, John D.	Kozma, Robert B.	Songer, Nancy Butler
Cognition and Technology Group at Vanderbilt	Pea, Roy D.	Vye, Nancy J.
Duffy, Thomas M.	Resnick, Mitchel	Young, Michael
	Roschelle, Jeremy	

Appendix B ☐ Authors who published in both ISD and LS publication outlets, in alphabetical order ($N = 66$).

Ahern, Terrence C.	Herrmann, Francoise	Pea, Roy D.
Barab, Sasha A.	Hickey, Daniel T.	Perkins, David N.
Beer, Martin	Hmelo, Cindy E.	Petrosino, Anthony J.
Bell, Philip	Howard, Bruce C.	Powers, Susan M.
Bonk, Curtis Jay	Hsi, Sherry	Repman, Judi
Bransford, John D.	Jackson, Randy	Resnick, Mitchel
Brophy, Sean P.	Jacobson, Michael J.	Roschelle, Jeremy
Campbell, Robert J.	Jonassen, David H.	Schwartz, Daniel L.
Cognition and Technology Group at Vanderbilt	Kantor, Ronald J.	Sharp, Diana L. M.
Collins, Allan	Kinzie, Mable B.	Shneiderman, Ben
Dede, Christopher J.	Kirschner, Paul A.	Slotta, James D.
Drake, Leston D.	Kozma, Robert B.	Songer, Nancy Butler
Driscoll, Marcy P.	Laffey, James	Spiro, Rand J.
Duffy, Thomas M.	Larsen, Valerie A.	Thiessen, Esther L.
Fairweather, Peter G.	Lin, Xiaodong	Tinker, Robert
Feltovich, Paul J.	Linn, Marcia C.	Towne, Douglas M.
Fishman, Barry J.	Marra, Rose M.	Vye, Nancy J.
Gay, Geri	Martin, David S.	Ward, Douglas R.
Goodrum, David A.	Mazur, Joan	Windschitl, Mark
Goodyear, Peter	McGee, Steven	Winn, William D.
Hay, Kenneth E.	Munro, Allen	Young, Michael
Henning, Philip	Musser, Dale R.	
	Nelson, Wayne A.	